# Stoichiometry: Mass-Mass Problems

**Unit:** Stoichiometry

**MA Curriculum Frameworks (2016):** HS-PS1-7

**Mastery Objective(s):** (Students will be able to…)

- Solve stoichiometry problems that require mole conversions.

**Success Criteria:**

- Conversions between moles and other quantities are set up and executed correctly.
- For each compound in the chemical equation, the ratio of the coëfficients is the same as the ratio of the moles.
- Algebra and rounding to appropriate number of significant figures is correct.

**Tier 2 Vocabulary:** mole, coëfficient

**Language Objectives:**

- Explain the order of operations: convert to moles, do stoichiometry, convert from moles to desired units.

## Notes:

stoichiometry: measurement of how much of each reactant is used and how much of each product is produced in a chemical reaction.

Remember that stoichiometry has to be done in moles.

- If you are given amounts in any other unit, you need to convert to moles before doing stoichiometry.
- If your answer needs to be in another unit, you need to convert after doing stoichiometry.

mass-mass problem: a stoichiometry problem that requires mole conversions from mass of a reactant to moles, and then moles of a product back to mass.

Note that there are many other similar problems that would work the same way—*e.g.,* from volume of a gas (using the ideal gas law) to moles, from volume of a liquid that has a certain concentration (in $\frac{\text{mol}}{\text{L}}$) to moles, *etc.*

Use this space for summary and/or additional notes:

**Sample Problem:**

How many grams of copper metal would be produced from 13.5 g of aluminum and excess copper chloride solution in the chemical reaction:

$$2\ Al_{(s)} + 3\ CuCl_{2\ (aq)} \rightarrow 2\ AlCl_{3\ (aq)} + 3\ Cu_{(s)}$$

**Strategy:**

1. Convert grams of Al to moles.
2. Use stoichiometry to convert moles of Al to moles of Cu.
3. Convert moles of Cu to grams.

**Setup:**

$$\frac{13.5\,\cancel{g\,Al}}{1} \times \frac{1\,\cancel{mol\,Al}}{27.0\,\cancel{g\,Al}} \times \frac{3\,\cancel{mol\,Cu}}{2\,\cancel{mol\,Al}} \times \frac{63.5\,g\,Cu}{1\,\cancel{mol\,Cu}}$$

**Answer:**

$$\frac{(13.5)(3)(63.5)}{(27.0)(2)} = \frac{2572}{54.0} = 47.6\,g\,Cu$$

<u>theoretical yield</u>: the amount of a product you could make based on stoichiometry calculations, assuming that at least one of the reactants is completely used up.

<u>excess</u>: having more of a reactant than is needed. This means simply that there is "enough that you don't have to worry about using it all up." We will see problems in which this is not the case in the next section ("Limiting Reactant," starting on page 419.)

By this point in this course, you have undoubtedly figured out that most of the challenging problems you will encounter are created by stringing together a sequence of easy problems until it becomes hard to keep track of what you're doing. Stoichiometry is easy (once you get the hang of it). Mole conversions are easy (assuming you've got the hang of them). Combining the two looks hard, but it's just a sequence of easy problems.

Use this space for summary and/or additional notes:

## Homework Problems

1. In the chemical reaction:

$$2\ K + Cl_2 \rightarrow 2\ KCl$$

a. How many *moles* of KCl (F.W. $74.55\,\frac{g}{mol}$) would be produced from 2.50 g of K and excess $Cl_2$?

Answer: 0.0639 mol KCl

b. How many *grams* of KCl would be produced?

Answer: 4.76 g KCl

2. In the chemical reaction:

$$Na_2O + H_2O \rightarrow 2\ NaOH$$

a. If 124 g of $Na_2O$ (F.W. $61.98\,\frac{g}{mol}$) is reacted with excess $H_2O$, how many grams of NaOH (F.W. $40.00\,\frac{g}{mol}$) will be made?

Answer: 160. g NaOH

b. If, instead, you wanted to make 100. g of NaOH, how many grams of $Na_2O$ would you need?

Answer: 77.5 g NaOH

Use this space for summary and/or additional notes:

3. In the decomposition reaction:

$$2\ NaClO_3 \rightarrow 2\ NaCl + 3\ O_2$$

If you reacted 26.6 g of $NaClO_3$ (F.W. $106.44\ \frac{g}{mol}$), what volume of $O_2$ would you make at a pressure of 1.03 atm and a temperature of 30 °C?
(*Hint: Use PV = nRT.*)

Answer: 9.06 L $O_2$ (g)

4. Given the precipitation reaction:

$$3\ CaCl_2\ (aq) + 2\ Na_3PO_4\ (s) \rightarrow Ca_3(PO_4)_2\ (ppt) + 6\ NaCl\ (aq)$$

If you added an excess of powdered $Na_3PO_4$ to 100. mL of an $0.200\ \frac{mol}{L}$ solution of $CaCl_2$, how many grams of precipitate would form?
(Assume that all of the $Ca_3(PO_4)_2$ precipitates, and that all of the $Na_3PO_4$ dissolves.)

Answer: 2.07 g $Ca_3(PO_4)_2$ (ppt)

5. How many grams of precipitate would form if 94.6 g of $FeCl_3 \cdot 6\ H_2O$ crystals were added to an aqueous solution containing an excess of $Na_2SiO_3$?
(*Hint: you will need to predict the products and balance the equation in order to do the stoichiometry.*)

Answer: 50.5 g $Fe_2(SiO_3)_3$ (ppt)

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